

2.3.2 Methodology for Determining Invertebrate Species of Greatest Conservation Need

2.3.2.1 General Introduction

Almost 97 percent of all described animal species and more than three out of four species of all living plants and animals combined are invertebrates. Yet, with the exception of a few basic qualities shared by all living things, invertebrates fail to demonstrate a single trait in common. Rather, invertebrates are characterized by what they are not (e.g., they are *not* vertebrates) and thus are lumped into one vast and heterogeneous assemblage of organisms (Barth and Broshears 1982). This enormous invertebrate diversity is clearly and dramatically reflected in their numerical preponderance, innumerable adaptations, and ecological variability and opportunism (Lutz 1986). Approximately 950,000 of the described invertebrate species are insects. The remainder fall into a variety of phyla encompassing the range of diversity from sponges to mollusks to echinoderms.

A basic understanding of ecosystems and their component parts (e.g., species, communities, etc.) forms the foundation for dealing with practical natural resource problems. Although often overlooked and misunderstood, invertebrates play integral roles in every biotic community. Without invertebrates, all ecosystem-level biological processes (e.g., energy flow, decomposition, pollination, trophic organization, biological control) would collapse rapidly (Wilson 1987). Indeed, it has been argued that if invertebrates disappeared, loss of all other life forms would soon follow (Wilson 1987, 1992). Attempts to ensure ecosystem sustainability across a wide range of temporal and spatial scales will not be successful if they do not rely heavily on conservation and protection of invertebrate communities.

The remainder of this section is divided into five sections. The first section (2.3.2.2) discusses what is currently known (and not known) about invertebrates in Wisconsin. The following section (2.3.2.3) identifies those invertebrate species groups considered and not considered in the current Comprehensive Wildlife Conservation Plan planning effort. The third section (2.3.2.4) identifies some of the principal data sources used in preparing the list of invertebrate Species of Greatest Conservation Need. The next section (2.3.2.5) details how invertebrate species were categorized for conservation planning during preparation of the Comprehensive Wildlife Conservation Plan. The fifth section (2.3.2.6) details the rationale for inclusion of taxa on the list of invertebrate Species of Greatest Conservation Need. References cited in the text are listed in the Bibliography.

2.3.3.2 State of Scientific Knowledge and Process Used to Identify Invertebrate Species of Greatest Conservation Need

In order to effectively encompass the tremendous diversity of invertebrates (and the range of experts that work with invertebrates), invertebrate taxa were divided into three categories to simplify review and discussion. The three categories are:

1. Nonarthropod invertebrates.
2. Noninsect arthropods.
3. Insects.

While biologically these categories are somewhat artificial, they were chosen for practical reasons. First, in the case of the insects and the noninsect arthropods, the included taxa are biologically related and often studied together. Second, experts that work on a particular taxon often maintain at least a general familiarity with related or similar taxa (e.g., scientists working with spiders often are familiar with other arachnid groups, those working with cladocerans often are familiar with copepods and clam shrimp, etc.).

As an initial step in the process to identify invertebrate Species of Greatest Conservation Need, an assessment of the state of scientific knowledge regarding invertebrates in Wisconsin was conducted. This was done by using three questions believed to be keys to successful conservation planning:

1. What invertebrate species occur in Wisconsin?
2. How are these invertebrate species distributed in space and time?
3. What factors cause the observed distributions in Wisconsin?

Tables 2-23, 2-24, and 2-25 present the results of this exercise. In these tables, an asterisk (*) indicates that the question can be answered completely or almost completely (e.g., for question 1, survey work has been completed and a state checklist is available or could be compiled relatively easily to indicate what species occur in Wisconsin). A plus sign (+) indicates that a partial, but by no means complete, answer to the question is available (e.g., for question 2, a fair amount may be known about the distribution of some families or species, but not most others in the group). Finally, a minus sign (-) indicates that little or no progress has been made in obtaining answers to the questions (e.g., little or no survey work has been completed or basic taxonomy is in such a state of disarray that comprehensive surveys remain impractical).

Wisconsin DNR (WDNR) biologists prepared initial drafts of the tables based on an extensive review of available taxonomic and ecological literature. The tables were then shared with twenty-two experts throughout the state who are familiar with the various taxa. Experts included academic scientists and museum curatorial staff, as well as additional WDNR biologists. Nine individuals responded to the peer review opportunity. The tables were modified to address input received in this peer review process. It was not always possible (or appropriate) to use a single symbol when completing the tables. For example, an asterisk/plus (*/+) marking indicates that considerable work has been completed on the taxa and a comprehensive species list is available, but additional species will likely be found in the state with additional survey work. This is sometimes the case because only limited habitats have been surveyed (e.g., grasshoppers have not been surveyed extensively in forests).

Due to time constraints associated with the overall Comprehensive Wildlife Conservation Plan process and the lack of active investigators working on Wisconsin invertebrate fauna, it was not feasible to contact experts on every invertebrate species group included in the tables. Thus, this assessment should be reviewed by additional experts and revised as necessary and appropriate.

The following tables demonstrate that basic information is lacking, e.g., species lists, for most Wisconsin invertebrate groups. From a conservation biology standpoint, the single greatest difficulty researchers and managers face is the lack of readily available, easy-to-use keys for the accurate identification of invertebrate species. This is confounded by the unstable taxonomy in many groups and the lack of investigators working on others. Most taxonomists spend years, even decades, learning the organisms, the literature, and the ecosystems in which the organisms are found. In most cases this, unfortunately, is not a science that can be performed by amateurs. Incorrect identification leads to confusion, poor interpretation of inventory data, and ultimately, poor decisions regarding resource protection and management.

A note on nomenclature

When dealing with invertebrates, it is often necessary to reconcile conflicts in the scientific nomenclature used by different researchers. Such conflicts result from advances in the description and documentation of previously undescribed invertebrate species and a changing understanding of evolutionary relationships.

Correct identification is vital to the protection of our natural resources, our health, and our environment. Furthermore, identification of pests and diseases must be accurate and timely if we are to sustain the mainstay of our economy – that is our forest, fisheries, and agricultural resources.

- Ian Efford, *Systematics: An Impending Crisis* (1995)

To ensure the most up-to-date taxonomic labels, scientific names from the Tree of Life Web Project (The University of Arizona 2004) were used. The Tree of Life is a collaborative effort of biologists from around the world. On more than 3,000 Internet web pages, the project provides information about the diversity of organisms on Earth, their evolutionary history, and characteristics. Each page contains information about a particular group of organisms. Tree of Life pages are linked to each other hierarchically, in the form of an evolutionary tree of life that illustrates the genetic connections between living things. Visitors to the Tree of Life web site can download the entire structure of the phylogenetic tree to examine relationships between organisms. These data are updated weekly to reflect current taxonomic understanding. This information can be accessed at <http://tolweb.org/tree/phylogeny.html>.

Standardized common names for invertebrate species included on the list of Species of Greatest Conservation Need were used as much as possible. Many invertebrates, however, do not have common names. NatureServe's database (NatureServe 2004) was used as a source of common names. Common names of some groups of species were updated using standard references (e.g., Stark 1998).

Table 2-23. Nonarthropod Invertebrates - Assessment of Progress Toward Answering Three Questions Key to Conservation Planning.

- (*) = The question can be answered completely or almost completely (e.g., for question 1, a checklist is available or could be compiled relatively easily to indicate what species occur in Wisconsin).
 (+) = A partial, but by no means complete, answer is available (e.g., for question 2, scientists have a general sense of the species distributions in Wisconsin).
 (-) = Little or no progress has been made in obtaining an answer to the question (e.g., relatively little attention has been paid to the Wisconsin fauna).

Taxa	Key Questions		
	1. What species occur in Wisconsin?	2. How are the species distributed in space and time?	3. What factors cause the observed distributions in Wisconsin?
Porifera (sponges)	*	+	+
Cnidaria (hydra and "jellyfish")	-	-	-
Platyhelminthes: Turbellaria (flatworms)	-	-	-
Platyhelminthes: Trematoda (flukes)	+	-	-
Platyhelminthes: Cestoidea (tapeworms)	+	-	-
Nemertea (ribbon worms)	+	-	-
Nematoda (round worms)	+	+	-
Nematomorpha (horsehair worms)	*	-	-
Acanthocephala (spiny headed worms)	*	+	-
Gastrotricha (gastrotrichs)	-	-	-
Rotifera (rotifers)	+	+	-
Annelida: Oligochaeta (earthworms)	+	-	-
Annelida: Hirudinea (leeches)	*	+	+
Annelida: Branchiobdellida (crayfish worms)	+	-	-
Annelida: Aphanoneura (suction-feeding worms)	-	-	-
Annelida: Polychaeta (polychaete worms)	*	+	-
Entoprocta (<i>Urnatella</i>)	*	-	-
Ectoprocta (bryozoans)	+	-	-
Mollusca: Gastropoda (snails and slugs)	*	-	-
Mollusca: Pelecypoda (fingernail clams and freshwater mussels)	*	+	+

Table 2-24. Noninsect Arthropods - Assessment of Progress Toward Answering Three Questions Key to Conservation Planning.

- (*) = The question can be answered completely or almost completely (e.g., for question 1, a checklist is available or could be compiled relatively easily to indicate what species occur in Wisconsin).
 (+) = A partial, but by no means complete, answer is available (e.g., for question 2, scientists have a general sense of the species distributions in Wisconsin).
 (-) = Little or no progress has been made in obtaining an answer to the question (e.g., relatively little attention has been paid to the Wisconsin fauna).

Taxa	Key Questions		
	1. What species occur in Wisconsin?	2. How are the species distributed in space and time?	3. What factors cause the observed distributions in Wisconsin?
Crustacea: Anostraca (fairy shrimp)	*	+	-
Crustacea: Notostraca (tadpole shrimp)	+	-	-
Crustacea: Laevicaudata and Spinicaudata (clam shrimp)	+	-	-
Crustacea: Cladocera (water fleas)	*	-	-
Crustacea: Ostracoda (seed shrimp)	+	+	-
Crustacea: Copepoda (copepods)	*/+	+	-
Crustacea: Branchiura (fish lice)	+	+/-	-
Crustacea: Mysidacea (opossum shrimp)	*	-	-
Crustacea: Isopoda (sow bugs)	*	+	-
Crustacea: Amphipoda (scuds)	*	+	-
Crustacea: Decapoda (crayfish, freshwater shrimp)	*	*	+
Diplopoda (millipedes)	+	-	-
Paurapoda (paurapods)	-	-	-
Chilopoda (centipedes)	+	-	-
Symphyla (symphylans)	-	-	-
Arachnida: Psuedoscorpiones (pseudoscorpions)	+	-	-
Arachnida: Opiliones (daddy-long legs)	*	-	-
Arachnida: Araneae (spiders)	+	+	-
Arachnida: Acari (mites, ticks)	+	-	-
Pentastomida (tongue worms)	-	-	-
Tardigrada (water bears)	-	-	-

Table 2-25. Insects and Related Hexapoda – Assessment of Progress Toward Answering Three Questions Key to Conservation Planning.

- (*) = The question can be answered completely or almost completely (e.g., for question 1, a checklist is available or could be compiled relatively easily to indicate what species occur in Wisconsin).
 (+) = A partial, but by no means complete, answer is available (e.g., for question 2, scientists have a general sense of the species distributions in Wisconsin).
 (-) = Little or no progress has been made in obtaining an answer to the question (e.g., relatively little attention has been paid to the Wisconsin fauna).

Taxa	Key Questions		
	1. What species occur in Wisconsin?	2. How are the species distributed in space and time?	3. What factors cause the observed distributions in Wisconsin?
Hexapoda: Protura (proturans)	+	-	-
Hexapoda: Collembola (spring tails)	+	-	-
Hexapoda: Diplura (diplurans)	-	-	-
Insecta: Archaeognatha (bristletails)	-	-	-
Insecta: Thysanura (silverfish, fire brats)	*	-	-
Insecta: Ephemeroptera (mayflies)	*	+	+/-
Insecta: Odonata (dragonflies, damselflies)	*	+	+/-
Insecta: Plecoptera (stoneflies)	*	+	+/-
Insecta: Phasmida (stick and leaf insects)	+	-	-
Insecta: Orthoptera (grasshoppers, crickets, etc.)	+	+	-
Insecta: Dermaptera (earwigs)	*	+	-
Insecta: Dictyoptera (cockroaches, termites, mantids)	*	+	+/-
Insecta: Psocoptera (book lice, bark lice)			
Insecta: Phthiraptera (lice)	*	+	+/-
Insecta: Hemiptera (true bugs)	+	+/-	+/-
Insecta: Thysanoptera (thrips)	+	-	-
Insecta: Megaloptera (alderflies, dobsonflies, fishflies)	*	+	-
Insecta: Neuroptera (lacewings, ant lions, owlflies)	+	-	-
Insecta: Coleoptera (beetles)	+	+/-	+/-
Insecta: Strepsiptera (twisted-winged insects)	+	-	-
Insecta: Mecoptera (scorpionflies, hangingflies)	-	-	-
Insecta: Trichoptera (caddisflies)	*	+/-	+/-
Insecta: Lepidoptera (butterflies, moths)	+	+	+/-
Insecta: Diptera (flies)	+	+	+/-
Insecta: Siphonaptera (fleas)	+	+	-
Insecta: Hymenoptera (wasps, bees, ants, etc.)	*/+	+	+/

2.3.2.3 Invertebrate Taxa Considered/Not Considered in the Current Strategy

The state of scientific knowledge assessment was used to focus attention on groups for which there appeared to be adequate knowledge to be able to identify invertebrate Species of Greatest Conservation Need. Specifically, attention was first directed toward those groups in Tables 2-23, 2-24, and 2-25 that have two or three plus [+] signs indicating sufficient progress has been made in answering the basic biological questions.

There are several taxa for which basic taxonomic and life history information remains lacking. These groups have two or three minus [-] signs in Tables 2-23, 2-24, and 2-25, indicating little progress has been made in answering the three basic conservation questions (e.g., cnidarians, gastrotrichs, etc.). Biologists know a fair amount about the biology and distribution of some other groups (e.g., sponges, leeches), but current status and survey information remains inadequate for determining Species of Greatest Conservation Need. Some taxa include mostly exotic, accidental, or migrant species. For example, most terrestrial earthworms are known to be introduced exotic species. Relatively little, however, is known about the native earthworms and some of these may be of conservation concern. Sufficient information to assess the status of these organisms in Wisconsin is simply just not available, as more is known about the exotics than the native species. Similarly, while a fair number of parasitologists have worked on the Wisconsin fauna, most parasitic taxa (e.g., flatworms, horsehair worms) remain poorly known. It is possible that conservation of vertebrate hosts will contribute to the conservation of their parasites. As a result of these uncertainties, invertebrate species within these groups were not evaluated to determine if any could be considered Species of Greatest Conservation Need. Invertebrate taxa not considered as part of this planning effort to identify Species of Greatest Conservation Need are listed in Table 2-22.

Table 2-26. Invertebrate Taxa Not Reviewed for Species of Greatest Conservation Need Status in Current Planning Effort.

Porifera (sponges)	Cnidaria (hydra and "jellyfish")	Platyhelminthes (flatworms, flukes, tapeworms)
Nemertea (ribbon worms)	Nematoda (round worms)	Nematomorpha (horsehair worms)
Acanthocephala (spiny headed worms)	Gastroticha (gastrotrichs)	Rotifera (rotifers)
Annelida (segmented worms)	Entoprocta (<i>Urnatella</i>)	Ectoprocta (bryozoans)
Crustacea: Notostraca (tadpole shrimp)	Crustacea: Branchiura (fish lice)	Diplopoda (millipedes)
Chilopoda (centipedes)	Paurapoda (paurapods)	Symphyla (symphylans)
Arachnida: Pseudoscorpiones (pseudoscorpions)	Arachnida: Opiliones (daddy-long legs)	Arachnida: Acari (mites, ticks)
Pentastomida (tongue worms)	Tardigrada (water bears)	Hexapoda: Protura (proturans)
Hexapoda: Collembola (springtails)	Hexapoda: Diplura (diplurans)	Insecta: Archaeognatha (bristletails)
Insecta: Thysanura (silverfish, fire brats)	Insecta: Phasmida (stick and leaf insects)	Insecta: Dermaptera (earwigs)
Insecta: Dictyoptera (cockroaches, termites, mantids)	Insecta: Psocoptera (book lice, bark lice)	Insecta: Phthiraptera (lice)
Insecta: Thysanoptera (thrips)	Insecta: Neuroptera (lacewings, ant lions, owlflies)	Insecta: Strepsiptera (twisted-winged insects)
Insecta: Mecoptera (scorpionflies, hangingflies)	Insecta: Siphonaptera (fleas)	Hymenoptera (bees, ants, etc.)

Biologists have studied one or more individual species of some invertebrate groups and a fair amount is known about the biology and distribution of some families or species groups within larger taxa. For example, tiger beetles and aquatic beetles are comparatively well known, but most other groups of beetles remain poorly known. Similarly, recent work in Wisconsin grasslands has yielded information about the biology, distribution, and status of certain hemipterans and orthopterans. Surveys also have provided a considerable amount of data on the distribution and status of butterflies and larger moths, but most microlepidopterans remain unknown in the state. Similarly, in aquatic ecosystems, much is known about the distribution of mussels, but little is known about the occurrence of fingernail clams. In addition, the invertebrate team and outside experts reviewed one group, the Megaloptera, and found no species to be Species of Greatest Conservation Need. Therefore, this group is not considered elsewhere in this plan. Table 2-27 presents those taxa for which only certain families or species groups were reviewed for Species of Greatest Conservation Need status during the current planning effort.

Table 2-27. Invertebrate Taxa for which Only Certain Families or Species Groups were Reviewed for Species of Greatest Conservation Need Status During the Current Planning Effort.

Mollusca: Pelecypoda (fingernail clams)	Crustacea: Copepoda (copepods)	Crustracea: Isopoda (sow bugs)
Crustacea: Amphipoda (scuds)	Arachnida: Araneae (spiders)	Insecta: Orthoptera (grasshoppers, crickets, etc.)
Insecta: Hemiptera (true bugs)	Insecta: Coleoptera (beetles)	Insecta: Lepidoptera (butterflies and moths)
Insecta: Diptera (flies)		

Many of the taxa listed in Tables 2-26 and 2-27 are considered to be invertebrate species or species groups of unknown conservation need ("Category 2", see Section 2.3.2.5 below).

2.3.2.4 Important Invertebrate Data Sources

The Comprehensive Wildlife Conservation Plan Invertebrate Species Team consulted the Natural Heritage Inventory Database (BIOTICS) as a primary source of information on invertebrates for which occurrence data has been collected and compiled previously. The Invertebrate Species Team also relied heavily on consultation with the experts who previously contributed information to BIOTICS and an extensive review of literature related to the various invertebrate taxa occurring in Wisconsin.

Besides BIOTICS, other important sources used for this effort included the Wisconsin Macroinvertebrate Database, a special database maintained by the Natural Heritage Inventory program. The Wisconsin Macroinvertebrate Database includes the "Biomonitoring Database" maintained by Dr. Stan Szczytko, University of Wisconsin-Stevens Point under contract with WDNR for assessment of Wadeable Streams (Lillie et al. 2003). The Wisconsin Macroinvertebrate Database uses the same general database structure, but also includes aquatic invertebrate species occurrence data from:

- biotic inventories conducted by Natural Heritage Inventory staff on WDNR's larger properties as part of property master planning efforts,
- inventory work conducted as part of the Lake Superior Basin Coastal Wetland Evaluation,
- several mayfly and dragonfly status surveys, including those for Hine's emerald dragonfly, stream dragonflies, and mayflies under review for federal listing, and the U.S. Forest Service's "Sensitive Species" in Wisconsin,
- WDNR's ongoing Odonate Atlas Pilot Project,
- inventory work completed as part of the WDNR's Bureau of Endangered Resources' Peatlands Project,

- Environmental Review assessments and monitoring conducted for proposed mines, wastewater treatment facilities, etc.,
- reports from peer reviewed literature,
- reliable reports from unpublished “gray” literature,
- museum log data (Odonata only), and
- some agency mussel surveys (mussel data are managed in a separate database maintained by WDNR).

Currently, the Wisconsin Macroinvertebrate Database documents around 20,000 collection efforts in aquatic or wetland habitats with about 286,000 invertebrate species occurrence records representing approximately 4,000 different taxa. The Wisconsin Macroinvertebrate Database serves as the main data-handling tool for all aquatic macroinvertebrate species and some terrestrial invertebrates addressed by the Natural Heritage Inventory. The Natural Heritage Inventory (rare species) database coverage of macroinvertebrates is largely derived by periodically querying the Wisconsin Macroinvertebrate Database.

A long-term project lead by WDNR biologists Rich Henderson and Scott Sauer has been documenting invertebrate species, primarily insects, within grassland habitats. The study has produced a large volume of terrestrial insect occurrences. Between 1992 and 2004, the study made or documented well over 2,000 site visits on approximately 370 sites yielding about 1,900 taxa and nearly 30,000 specimens. Periodically, project biologists have provided the Natural Heritage Inventory program with recommendations of potentially rare species. The Natural Heritage Inventory so far has tracked only obligate grassland species that are probably rare globally and may be sensitive to certain management practices. The Invertebrate Species Team consulted project biologists and considered their complete data set in developing the list of Species of Greatest Conservation Need.

The Invertebrate Species Team also consulted several on-line databases maintained by the Milwaukee Public Museum. The Wisconsin Crustaceans Homepage (Milwaukee Public Museum 2004a) is based on Milwaukee Public Museum crustacean collections and research. The internet web site (<http://www.mpm.edu/collect/invert/jass/Default.asp>) primarily focuses on crayfish, with images and data from the book *The Crayfishes and Shrimp of Wisconsin* (Hobbs and Jass 1998). It also includes data on fairy shrimp, amphipods, and isopods, as well as other crustaceans. Similarly, the Milwaukee Public Museum's Mathiak Collection of Freshwater Mussels of Wisconsin (Milwaukee Public Museum 2004b) contains significant holdings from Wisconsin, a major portion being mussels collected by Harold A. Mathiak, who surveyed 251 rivers and creeks across Wisconsin (641 sites) during the 1970s. Voucher specimens (7000+) with the pertinent date, stream, county, and township/range/section data were donated to six institutions including the Milwaukee Public Museum. The Mathiak Collection provides a good source of material for addressing various research and conservation questions. The Milwaukee Public Museum Mollusk Collection web site offers a searchable, composite database of this collection. It can be accessed at <http://www.mpm.edu/collect/invert/mussels/default.asp>.

2.3.2.5 Categorizing Invertebrate Species of Greatest Conservation Need

After the initial step of developing the state of scientific knowledge tables (Section 2.3.2.2), the next step was to take a look at the subset of invertebrate groups for which it was determined there was adequate knowledge to allow for analysis in this first iteration of the Comprehensive Wildlife Conservation Plan. Unlike the vertebrate groups, there was not the same breadth or depth of data and information to draw from in determining what invertebrate species are of greatest conservation need. That said, criteria were written to parallel the vertebrate process. Staff and partner invertebrate experts statewide were enlisted to develop the list of 530 invertebrate Species of Greatest Conservation Need. These species span 19

groups, of which 58 invertebrate species are non-arthropod invertebrates, 22 are non-insect arthropods, and 450 are insects.

With the list of 19 groups that were going to be addressed in the plan, a letter was sent out to various invertebrate species experts inside and outside the WDNR. The letter explained the criteria for identifying invertebrate Species of Greatest Conservation Need. Invertebrate species were identified as such if they were:

1. state and/or federally listed,
2. of special concern and having a Natural Heritage Inventory State Rank of S1 or S2 and/or Global Rank of G1-G3, or
3. nominated by a species expert and accepted by the Invertebrate Species Team.

State Ranks and Global Ranks provide basic information on the relative imperilment or vulnerability of a species within the specified geographic ranges based on a five-point hierarchical scale, ranging from critically imperiled (S1, G1) to demonstrably widespread, abundant and secure (S5, G5) (NatureServe, 2002).

Rationale for nomination and acceptance in this category considered whether the species is declining; endemic; disjunct; with small, localized “at-risk” populations; with limited dispersal; with fragmented or isolated populations; *and/or* species of special or conservation concern (in addition to S1 or S2 and/or G1-G3).

Draft lists of species for many groups were provided to experts based on the first two criteria. Experts were asked to nominate species they thought also merited consideration given the rationales listed in criteria 3. The Invertebrate Species Team then considered the nominations for the final list of invertebrate Species of Greatest Conservation Need. Similar to the vertebrate process, there is a continuum of knowledge on invertebrate species in the state. In addition to invertebrate Species of Greatest Conservation Need (Category 1), three other categories of invertebrates (Category 2, 3, and 4) were created to describe the varying degrees of information available about these other species or groups of species.

Category 2 describes invertebrate species or species groups of unknown conservation need. This group was divided into three subgroups, which were:

1. Species or species groups for which basic taxonomy and/or life history research is needed;
2. Species or species groups for which taxonomy and life history are relatively certain, but their status is unknown; and
3. Species that are not listed as endangered or threatened in Wisconsin, but are listed as state threatened or endangered in an adjacent state (Illinois, Iowa, Michigan, or Minnesota). This category will be comprised of invertebrate species that may not be rare or declining in Wisconsin, but have been recognized as rare or declining elsewhere.

This category includes all of the taxa listed in Table 2-26 and not considered during the current planning effort.

Category 3 describes invertebrate species or species groups not identified as Species of Greatest Conservation Need of which a large portion of their continental population resides in Wisconsin. These will be invertebrate species that may not be rare or declining in Wisconsin, but species for which it should be noted that Wisconsin plays a significant role in their continued existence. This category could include many additional species currently included in Category 2. Further refinement of this third category remains underway and the list will evolve as knowledge of the various taxa increases.

Category 4 describes invertebrate species or species groups that are not of conservation need at this time. Species in this category include species with stable or growing populations, pest species, and introduced non-native species. As with Category 3, work to develop this fourth category more fully remains underway and the

list will evolve as knowledge of the various taxa increases. In addition, this category could include many additional species currently included in Category 2.

2.3.2.6. Rationale for Inclusion of Invertebrate Species as Species of Greatest Conservation Need

The following list by taxonomic group indicates the rationale for including species in each group on the list of Species of Greatest Conservation Need and the databases, literature, and experts consulted in the current planning process. Species groups are presented in taxonomic order.

Mollusca: Gastropoda (Snails)

The list of Species of Greatest Conservation Need includes 31 land snails. Numerous other snails are tracked as part of the Natural Heritage Inventory Working List (Natural Heritage Inventory 2004a). All snails included on the list of Species of Greatest Conservation Need are either state and/or federally listed or are considered of special concern and have a Natural Heritage Inventory State Rank of S1 or S2 and/or a Global Rank of G1, G2, or G3. The Invertebrate Species Team also considered the published works of invertebrate zoologist Joan P. Jass, Milwaukee Public Museum, Dr. Jeffery Nekola, University of Wisconsin-Green Bay, Dr. James Theler, University of Wisconsin-La Crosse, and Dr. Terrence Frest, a private consultant and snail expert. Information on the distribution and habitats of listed snail species is available in *The Endangered and Threatened Invertebrates of Wisconsin* (Wisconsin DNR 1999d).

Mollusca: Pelecypoda (Mussels)

The list of Species of Greatest Conservation Need includes 26 mussels. All mussels included on the list of Species of Greatest Conservation Need are either state and/or federally listed or are considered of special concern and have a Natural Heritage Inventory State Rank of S1 or S2 and/or a Global Rank of G1, G2, or G3. In addition to surveys conducted by the Natural Heritage Inventory Program, the Invertebrate Species Team considered works of and previous input from mussel experts Frank Baker, Harold Matthiak, David Heath, Marian Havlik, Sam Fuller, Thomas Doolittle, Mark Hove, and others. Important Museum collections accessed during preparation of the Natural Heritage Inventory working list included the Milwaukee Public Museum, the Bell Museum of Natural History, University of Wisconsin-Stevens Point, and the University of Wisconsin-Madison's Zoology Museum. Information on the distribution and habitats of listed mussels is available in *The Endangered and Threatened Invertebrates of Wisconsin* (Wisconsin DNR 1999d).

Annelida: Polychaeta (Annelid Worms)

The list of Species of Greatest Conservation Need includes one polychaete worm, *Manayunkia speciosa*. The inclusion of this annelid on the list of Species of Greatest Conservation Need is based on recommendations from Dr. Kurt Schmude, Lake Superior Research Institute, University of Wisconsin-Superior, based on his recent analysis of available data. Dr. Schmude has worked statewide for the past 10 years conducting aquatic invertebrate surveys for various resource agencies, including WDNR, and is currently relied on extensively for expertise by the Natural Heritage Inventory Program. In spite of extensive aquatic invertebrate sampling throughout the state, fewer than 250 specimens of this polychaete have been collected from only two counties in extreme northern Wisconsin and Lake Superior. The Invertebrate Species Team also consulted with Mark J. Wetzel, Illinois Natural History Survey, regarding annelids occurring in Wisconsin. Mr. Wetzel is a well-respected annelid taxonomist.

Crustacea: Anostraca (Fairy Shrimp)

The list of Species of Greatest Conservation Need includes all three of Wisconsin's fairy shrimp species. The inclusion of these species on the list is based on recommendations of zooplankton ecologist Dr. Stanley Dodson, University of Wisconsin, and invertebrate biologist Dr. Ed Stern, University of Wisconsin-Stevens Point, as well as the published works of invertebrate zoologist Joan P. Jass, Milwaukee Public Museum. Dr. Dodson and his colleagues have investigated zooplankton communities in the Great Lakes, small inland lakes, wetlands, and restored wetlands throughout the state for many years. Dr. Stern has spent many years investigating the fauna of Wisconsin's aquatic communities. Ms. Jass is a recognized expert on Wisconsin crustaceans. She and her colleagues published the first comprehensive treatments of Wisconsin fairy shrimp in the early 2000s. Wisconsin's fairy shrimp occur sporadically on the landscape and are dependent on ephemeral ponds, a habitat that is easily disturbed or destroyed.

Crustacea: Isopoda (Isopods, Sow Bugs)

The list of Species of Greatest Conservation Need includes one aquatic isopod, *Lirceus lineatus*. The inclusion of this sow bug on the list of Species of Greatest Conservation Need is based on recommendations from Dr. Kurt Schmude, Lake Superior Research Institute, University of Wisconsin-Superior. Dr. Schmude has worked statewide for the past 10 years conducting aquatic invertebrate surveys for various resource agencies, including WDNR, and is currently relied on extensively for expertise by the Natural Heritage Inventory Program. Biologists have collected fewer than 100 specimens of this species from only two Wisconsin counties (Ashland and Door). The Invertebrate Species Team also considered the published works of invertebrate zoologist Joan P. Jass, Milwaukee Public Museum, when assessing the isopods for Species of Greatest Conservation Need.

Crustacea: Amphipoda (Amphipods)

The list of Species of Greatest Conservation Need includes three amphipods. The Wisconsin well amphipod (*Stygobromus putealis*) is endemic to Wisconsin, occupies subterranean groundwater, and is known from only four wells and a spring in Dodge, Fond du Lac, and Green Lake counties in central Wisconsin. The inclusion of this amphipod on the list of Species of Greatest Conservation Need was based on current recommendations of Dr. Kurt Schmude, Lake Superior Research Institute, University of Wisconsin-Superior, and prior recommendations of invertebrate zoologist Joan P. Jass, Milwaukee Public Museum. Dr. Schmude has worked statewide for the past 10 years conducting aquatic invertebrate surveys for various resource agencies, including WDNR, and is currently relied on extensively for expertise by the Natural Heritage Inventory Program. Ms. Jass is an expert on Wisconsin crustaceans and is responsible for most of the recent publications on the group. Dr. Schmude also recommended inclusion of the other two amphipods. These two species appear to be extremely rare in the state and have been collected only sporadically.

Crustacea: Laevicaudata (Clam Shrimp)

The list of Species of Greatest Conservation Need includes one clam shrimp, *Lynceus brachyurus*, for which very few Wisconsin records are available. The inclusion of this clam shrimp on the list of Species of Greatest Conservation Need is based on recommendations from Dr. Stanley Dodson, University of Wisconsin, and Dreux Watermolen, WDNR. Dr. Dodson, a zooplankton ecologist, and his colleagues have investigated zooplankton communities in the

Great Lakes, small inland lakes, and natural and restored wetlands throughout the state for many years. Mr. Watermolen has been working to document Wisconsin's non-insect invertebrate fauna for more than 15 years.

Crustacea: Copepoda (Copepods)

Zooplankton ecologist Dr. Stanley Dodson, University of Wisconsin, and Dreux Watermolen, WDNR, recommended four copepods for inclusion on the list of Species of Greatest Conservation Need. The Invertebrate Species Team also considered the published work of Dr. Byron Torke, Ball State University. Dr. Dodson, a zooplankton ecologist, and his colleagues have investigated zooplankton communities in the Great Lakes, small inland lakes, and natural and restored wetlands throughout the state for many years. Mr. Watermolen has been working to document Wisconsin's non-insect invertebrate fauna for more than 15 years. In the early 2000s, Dr. Torke published information collected over 30 years on the distribution of calanoid copepods in Wisconsin lakes. Dr. Torke's work included over 1,500 samples from 499 lakes in 63 of Wisconsin's 72 counties. Many of the lakes included in Dr. Torke's paper were sampled 4 times over a year-long period to obtain seasonal information. Earlier work by Torke on 190 Wisconsin lakes was published in the late 1970s and was also considered. The copepods considered Species of Greatest Conservation Need occupy two primary habitats: pristine marshes and kettles in southern Wisconsin and deep cold high-oxygen water usually in northern Wisconsin. The harpacticoid and cyclopoid copepods were not considered in the current planning effort due to a lack of adequate information.

Crustacea: Decapoda (Crayfishes and Shrimp)

Information on the distribution and abundance of crayfishes and shrimp was collected as part of the statewide fish distribution survey in the 1970s and early 1980s. Dr. Horton Hobbs, III, Wittenberg University, and invertebrate zoologist Joan P. Jass, Milwaukee Public Museum, supplemented these collections with focused field collecting efforts in 1982 and a review of numerous museum collections, before publishing *The Crayfishes and Shrimp of Wisconsin* (Hobbs and Jass 1988). Dr. Hobbs and Ms. Jass examined over 13,650 specimens during their study. The inclusion of several decapods on the Natural Heritage Inventory Working List was based in part on this extensive baseline work. Dr. Ed Stern, University of Wisconsin-Stevens Point, Dr. Kurt Schmude, Lake Superior Research Institute, University of Wisconsin-Superior, and Dreux Watermolen, WDNR, recommended species for inclusion on the list of Species of Greatest Conservation Need. Dr. Stern has spent many years investigating the fauna of Wisconsin's aquatic communities. Dr. Schmude has worked statewide for the past 10 years conducting aquatic invertebrate surveys for various resource agencies, including WDNR, and is currently relied on extensively for expertise by the Natural Heritage Inventory Program. Mr. Watermolen has been working to document Wisconsin's non-insect invertebrate fauna for more than 15 years.

Arachnida: Araneae (Spiders)

The list of Species of Greatest Conservation Need includes 6 spiders. Comprehensive surveys of Wisconsin spiders have not been completed, but some inventory work has occurred. The Natural Heritage Inventory Working List includes only a handful of spider species. Dr. Michael Draney, University of Wisconsin-Green Bay, recommended additional spiders for inclusion on the list of Species of Greatest Conservation Need, based on an assessment of all available published spider distribution information. Those species include in the list have been collected only sporadically

in the state. Dr. Draney and colleagues have been compiling a checklist of Wisconsin (and Great Lakes region) spiders. The Invertebrate Species Team reviewed Dr. Draney's recommendations.

Insecta: Ephemeroptera (Mayflies)

The list of Species of Greatest Conservation Need includes 54 mayflies. The original submissions for the Natural Heritage Inventory Working List were from ecologist Dick Lillie, WDNR, with additional input from Dr. Bill Hilsenhoff, University of Wisconsin-Madison, and Dr. Stan Szczytko, University of Wisconsin-Stevens Point. Natural Heritage Inventory program staff conducted a status survey of mayfly species that were being considered for federal listing. Dick Lillie, the principal investigator, published these results in a WDNR *Technical Bulletin*. Recent review of collections around the United States has resulted in a number of new globally rare taxa being reported from Wisconsin. These species are now tracked by the Natural Heritage Inventory. A number of additional species were recommended by Dr. Kurt Schmude, Lake Superior Research Institute, University of Wisconsin-Superior, as Species of Greatest Conservation Need based on recent analysis of available data. The Invertebrate Species Team reviewed Dr. Schmude's recommendations.

Insecta: Odonata (Dragonflies)

The list of Species of Greatest Conservation Need includes 42 dragonflies. The Natural Heritage Inventory list was first developed in the late 1980s with significant input from Tim Vogt and Tim Cashatt, odonatologists from the Illinois State Museum. Since then, this group has received a fair amount of attention and has been addressed by various status surveys, biotic inventories, reviews related to the federally endangered Hine's emerald dragonfly, and other sources. Many species originally thought to be quite rare in Wisconsin have turned out to not be of conservation concern and the Natural Heritage Inventory Working List has been changed several times to reflect the current population assessment resulting from surveys and compilation of available data. Recommendations for Species of Greatest Conservation Need were made primarily by William Smith, WDNR, with significant input from Robert DuBois, WDNR. Information on the distribution and habitats of state listed dragonflies is available in *The Endangered and Threatened Invertebrates of Wisconsin* (Wisconsin DNR 1999d).

Insecta: Plecoptera (Stoneflies)

The list of Species of Greatest Conservation Need includes 12 stoneflies. Natural Heritage Inventory recommendations originally came from Dr. Bill Hilsenhoff, University of Wisconsin-Madison, as a result of his extensive work on aquatic insects described under the aquatic beetle section below. Dr. Stan Szczytko, University of Wisconsin-Stevens Point, a stonefly taxonomist, has provided continual input to the Natural Heritage Inventory Working List and has recommended several additional species for consideration as Species of Greatest Conservation Need. The Invertebrate Species Team reviewed and accepted Dr. Szczytko's recommendations.

Insecta: Orthoptera (Grasshoppers, Crickets)

The list of Species of Greatest Conservation Need includes 42 grasshoppers. The Natural Heritage Inventory Working List of rare grasshoppers, crickets, and allies is based on recommendations from Kathryn Kirk, a conservation biologist with the Natural Heritage Inventory program, and Dr. Chuck Bomar, University of Wisconsin-Stout. These two individuals have been atlas-ing orthopteran records for the past several years and recently published a

manuscript summarizing Wisconsin records. Natural Heritage Inventory has addressed this group in some of the more recent biotic inventory projects it has undertaken. Species of Greatest Conservation Need recommendations came from Kathryn Kirk and were reviewed and accepted by the Invertebrate Species Team.

Insecta: Hemiptera (Bugs)

The list of Species of Greatest Conservation Need includes 54 true bugs. Dr. Bill Hilsenhoff, University of Wisconsin-Madison, and Dr. Kurt Schmude, Lake Superior Research Institute, University of Wisconsin-Superior, with additional input from Richard Lillie and Richard Narf, WDNR, and Dr. Stan Szczytko, University of Wisconsin-Stevens Point, made recommendations for aquatic true bugs on the current Natural Heritage Inventory Working List. Aquatic true bug species recommendations for the invertebrate Species of Greatest Conservation Need list came primarily from Dr. Kurt Schmude based on comprehensive review of previous efforts in Wisconsin described under the Coleoptera.

True Bugs (*Insecta: Heretoptera [Homoptera]*) - A long-term WDNR project documenting invertebrate species on grassland habitats has produced a large volume of terrestrial insect occurrences. Between 1992 and 2004, this study made or documented well over 2,000 site visits on approximately 370 sites yielding about 1,900 taxa and nearly 30,000 specimens. Project biologists Rich Henderson and Scott Sauer, WDNR, have periodically provided the Natural Heritage Inventory program with recommendations of potentially rare species. The Natural Heritage Inventory so far has tracked only obligate grassland species that are probably globally rare and may be sensitive to certain management practices. These have tended to be primarily members of the Homoptera, including leafhoppers, treehoppers and spittlebugs. Dr. Andy Hamilton, Agriculture Canada, remains an important consulting expert for Wisconsin Homoptera. Many additional recommendations from this study have resulted in a number of additions to the Category 2 invertebrate list as described in Section 2.3.2.5.

Insecta: Coleoptera (Beetles)

The list of Species of Greatest Conservation Need includes 154 beetles. Aquatic beetles on the current Natural Heritage Inventory Working List were based on recommendations from a number of experts including primarily Dr. Bill Hilsenhoff, University of Wisconsin-Madison, Dr. Kurt Schmude, University of Wisconsin-Superior, Richard Lillie and Richard Narf, WDNR, Dr. Stan Szczytko, University of Wisconsin-Stevens Point, and Richard Bautz, WDNR. Dr. Hilsenhoff, an aquatic entomologist now retired from the University of Wisconsin-Madison, had systematically sampled all of Wisconsin's counties at least three times between the late 1960s and the mid-1990s for aquatic beetle and true bug species. His publications documenting Wisconsin's aquatic insects began in 1984 and continued through 1995. Dr. Schmude, Lake Superior Research Institute, University of Wisconsin-Superior, was a student of Dr. Hilsenhoff and has continued to build on aquatic insect records assembled by Dr. Hilsenhoff. Dr. Schmude has worked statewide for the past ten years on aquatic invertebrate surveys for the WDNR, U.S. Geological Survey, counties, consulting firms, and Native American Tribes and is currently relied on extensively for expertise in aquatic entomology by the Natural Heritage Inventory Program. Recommendations for Species of Greatest Conservation Need came primarily from Dr. Kurt Schmude, integrating the work mentioned above, and were reviewed and accepted by the Invertebrate Species Team.

Terrestrial beetles on the Natural Heritage Inventory Working List include predominantly tiger beetles, one scarab beetle, and the extirpated American burying beetle. Beetle experts Matt Brust,

Dr. Harold Willis, Wayne Steffens, and William Smith made recommendations for tiger beetles for inclusion on the Natural Heritage Inventory Working List. Tiger beetles were covered in several biotic inventory projects conducted by Natural Heritage Inventory program and are relatively well known in Wisconsin. Dr. Dan Young, University of Wisconsin, and others conducted surveys for the federally endangered American burying beetle in Wisconsin. Dr. Young has also overseen projects to survey other beetle groups in Wisconsin. Kathryn Kirk, WDNR, recommended the scarab beetle. The Invertebrate Species Team drew Species of Greatest Conservation Need almost entirely from the Natural Heritage Inventory Working List and through consultation with tiger beetle expert Matt Brust.

Insecta: Trichoptera (Caddisflies)

The list of Species of Greatest Conservation Need includes 37 caddisflies. Natural Heritage Inventory recommendations originally came from Dr. Bill Hilsenhoff, University of Wisconsin, as a result of his extensive work on aquatic insects described under the aquatic beetle section above. Additional input was received from Dr. Kurt Schmude, University of Wisconsin-Superior, Dr. Stan Szczytko, University of Wisconsin-Stevens Point, and Dick Lillie and Richard Narf, WDNR. Several additional species were recommended as Species of Greatest Conservation Need by Dr. Schmude.

Insecta: Lepidoptera (Butterflies and Moths)

The list of Species of Greatest Conservation Need includes 29 butterflies and 17 moths. The Natural Heritage Inventory list developed with significant input from Les Ferge, a moth taxonomist from Middleton, Wisconsin, Susan Borkin of the Milwaukee Public Museum, and other members of the Wisconsin Entomological Society. Subsequent revisions were based on recommendations primarily from Mr. Ferge. Ms. Borkin provided submissions of Species of Greatest Conservation Need. Occurrence data were drawn from a large number of collections, studies, reports, and other sources over the past several decades on this popular group. Much of the work has focused on species of grasslands and barrens or on rare species. A large set of data resulted from surveys related to the federally listed Karner blue butterfly.

Insecta: Diptera (Flies)

The list of Species of Greatest Conservation Need includes nine flies. The few species tracked by Natural Heritage Inventory are aquatic and are known only from larvae. These larvae are identifiable to genus but not species. The genera themselves, however, are rare in Wisconsin. Since a species name is not available until the larvae can be reared to the adult stage, there are no corresponding Element Codes or Natural Heritage Inventory records. These aquatic flies were recommended for the Natural Heritage Inventory list by Dr. Kurt Schmude, Lake Superior Research Institute, University of Wisconsin-Superior, and reiterated by him as Species of Greatest Conservation Need. The Invertebrate Species Team accepted his recommendations due to the rarity of the genera.